

**FINAL SURVEY REPORT:  
ERGONOMICS ENGINEERING INTERVENTIONS  
FOR SHIP CONSTRUCTION PROCESSES**

**at**

**JEFFBOAT LLC  
Jeffersonville, Indiana**

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4676 Columbia Parkway, Mailstop C-24  
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<b>PLANT SURVEYED:</b>	Jeffboat LLC, A unit of American Commercial Lines Holdings LLC, 1030 East Market Street Jeffersonville, Indiana 47130-4330
<b>SIC CODE:</b>	3731
<b>SURVEY DATE:</b>	November 9-10, 1999
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## **DISCLAIMER**

Mention of company names and/or products does not constitute endorsement by the Centers for Disease Control and Prevention (CDC).

## **ABSTRACT**

A pre-intervention quantitative risk factor analysis was performed at various shops and locations within Jeffboat LLC, a builder of river barges in Indiana, as a method to identify and quantify risk factors that workers may be exposed to in the course of their normal work duties. Four locations were identified: the rake frame subassembly process, the unloading of angle irons in the steelyard, the honeycomb confined space welding process for double hull barges, and the shear press operation in the plate shop. Possible engineering interventions to address the risk factors associated with these processes were discussed in the interim survey report. This report summarizes the actions taken by the shipyard to address these or any other pertinent ergonomic issues.

## **I. INTRODUCTION**

### **IA. BACKGROUND FOR CONTROL TECHNOLOGY STUDIES**

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency in occupational safety and health research. Located in the Department of Health and Human Services, it was established by the Occupational Safety and Health Act of 1970. Since 1976, NIOSH has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques. The objective of each of these studies has been to document and evaluate effective control techniques for potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of an effective system of hazard control measures. Initially, a series of walk-through surveys are conducted to select plants or processes with effective and potentially transferable control technology concepts or techniques. Next, in-depth surveys are conducted to determine both the control parameters and the effectiveness of these controls. The reports from these in-depth surveys are then used as a basis for preparing technical reports and journal articles on effective hazard control measures. Ultimately, the information from these research activities will build a database of publicly available information on hazard control techniques for use by health professionals who are responsible for preventing occupational illness and injury.

### **IB. BACKGROUND FOR THIS STUDY**

The background for this study may be found in the previous technical reports (EPHB Report No. 229-11a, "Preliminary Survey Report: Pre-Intervention Quantitative Risk Factor Analysis for Ship Construction Processes at Jeffboat LLC, Jeffersonville, Indiana," by Hudock et al (2000a) and EPHB Report No. 229-11b, "Interim Survey Report: Recommendations for Ergonomics Engineering Interventions for Ship Construction Processes at Jeffboat LLC, Jeffersonville, Indiana," by Hudock et al (2000b). Both of these reports are available on the NIOSH website: <http://www.cdc.gov/niosh/ergship/reports.html>.

### **IC. BACKGROUND FOR THIS SURVEY**

Jeffboat LLC is a private shipyard located in Jeffersonville, Indiana that performs primarily new vessel construction. This yard is considered to be a medium-to- small-size yard. The primary product of the yard is river barges of various configurations. Approximately 350 barges are completed each year. Jeffboat is a member of the Shipbuilders Council of America.

## **II. PLANT AND PROCESS DESCRIPTION**

### **IIA. INTRODUCTION**

Plant Description: Jeffboat LLC calls itself “America’s Largest Inland Shipbuilder.” Jeffboat’s primary products are river barges and towboats. The shipyard facilities include over a mile of waterfront property, 4 drydocks and approximately 50 acres of property.

Corporate Ties: A unit of American Commercial Lines Holdings LLC

Products: Jeffboat produces approximately 350 barges per year in a variety of configurations based on client needs including: open hopper barges, double-hull liquid and chemical tankers, covered rake barges, and self-unloading cement barges. Occasionally towboats and paddlewheelers for the gaming and excursion industries have been built.

Age of Plant: The site of Jeffboat has been functioning as a shipyard since 1939. Most of the facility has been updated or rebuilt since that time.

Number of Employees, etc: Approximately 975 production employees, of which 169 were new hires with less than 90 days experience with the company at the time of the initial site visit. Approximately 45 per cent of the production workers are classified as welders. Annual turnover has historically been near 40 percent.

### **IIB. PROCESS DESCRIPTION**

#### **IIB1. Rake Frame Subassembly within Structural Shop**

Subassemblies such as rake frames, or the skeletal framework for the curved bows of tanker, chemical, and cargo barges are created within the Structural Shop. Jigs are set-up at ground level and welded in place on the steel deck floor. Angle irons are delivered by overhead crane to each subassembly area. Angle irons, some weighing up to approximately 240 pounds, are manually placed in the jig, usually by a single worker. Wedges are then hammered into place to secure the angle irons into the jig. Smaller angle irons are placed on the longer ones to form cross members. Flat iron plates are placed at the corners of the rake frame and are secured by the use of C-clamps. Workers stick weld the joints of the rake frame that face up. The shipfitter then knocks out the wedges securing the rake frame in the jig. The subassembly is picked up by the overhead crane, flipped over and stacked in a manner so that the other side of the joints can be welded.

During rake frame subassembly, shipfitters are required to work in awkward postures including extreme lumbar flexion that produces excessive loads to the low back. Musculoskeletal risk

factors include: extreme lumbar flexion, shoulder abduction, wrist flexion, both ulnar and radial deviation, and contact stresses, such as kneeling on hard surfaces.

## **II B2. Angle Iron Unload in Steelyard**

Raw material, primarily steel plate and angle irons, is brought to the shipyard by truck, train or barge. Material is placed within the steelyard by the use of an A-frame crane and stored outside until needed by the various production departments. When called for, the A-frame crane picks up a batch load of angle irons from the steelyard and transports it to an unloading station. A worker grabs hold of each individual iron with a toothed “gator” bar and flips it right side up onto a sorting table below. Two workers then pull the angle iron across the table either by hand or with large, long hooks and spread the angle irons across the roller conveyor. Once the angle irons are placed on the roller conveyor, they are transferred to a mobile conveyor section that takes them into the surface preparation area.

The gator bar worker experiences awkward postures including extreme lumbar flexion and excessive shoulder loads in separating the angle irons apart. The unload helpers also experience awkward postures including moderate lumbar flexion and moderate shoulder loads in pulling the angle irons across the roller conveyor.

## **II B3. Honeycomb Welding**

This process involved stick welding in confined spaces, known as honeycombs, which are steel compartments two feet by two feet by sixteen feet long within a double hulled barge bottom section. The bottom plate was welded to the vertical supports on both sides of the honeycomb. At the time of the site visit, a stick welding process was used. Typically 8-10 honeycombs could be completed in a shift by each welder. Ventilation was primarily by blower fan forcing outside air into the honeycomb. A detailed report on ventilation interventions for this process can be found in Wurzelbacher et al, 2002.

The welders assumed constrained postures in order to crawl to the far end of the honeycomb to begin welding. This task also included extreme lumbar flexion in confined spaces, contact stress on the knees and elbows, pulling and lifting weld leads into and out of the honeycomb, positioning the blower fan and moving it from one honeycomb to the next, and extreme environmental temperatures in summer and winter. This stick welding process has been replaced by an automated welding process that minimizes worker exposure to the previously perceived occupational risk factors.

#### **II B4. Shear Operation in Plate Shop**

The primary processes within the plate shop are to cut, size, and shape steel plate required for hulls and subassemblies using shear machines, automated plasma cutters, and manual cutting torches. At the shear, steel plates are moved to pallets next to shear by jib crane. Plates are lifted from pallet to shear by the crane and guided into the shear manually. The shear is activated and the cut plates fall to the back of the shear. The cut plates are sorted at the back of the shear at ground level and lifted into metal tubs for further distribution.

Shear operators often lift awkward loads from the ground-level shear chutes and material supply pallets. Contact stresses experienced by the shear operator include kneeling on the floor to get material and contact with the sharp edges of the raw or cut material.

### **III. CONTROL TECHNOLOGY**

#### **IIIA. Rake Frame Subassembly Intervention**

The primary concern with the rake frame subassembly process is the fact that both the shipfitter and welders must bend forward, or flex, at the waist to perform their work at toe height. This is due in part to the jig for the rake frame being welded directly to the steel floor. A height-adjustable jig (more accurately, a jig top placed on a lift table) was suggested as a possible solution, but was dismissed by the company due to perceived space constraints.

#### **IIIB. Angle Iron Unload in Steelyard Intervention**

The primary concern with the angle iron unload process in the steelyard is the movement of individual angle irons from the bundled stack table to the proper position on the roller conveyor. At one point, the shipyard had a number of engineers working on the design of a mechanized angle iron placement system. Unfortunately, the anticipated costs exceeded the capacity of this project to support the concept.

#### **IIIC. Confined Space Welding on Line Four Hull Possible Interventions**

Possible interventions for the confined space welding process at this shipyard are detailed in the report by Wurzelbacher et al, 2000. In summary, the interventions include the change in weld process from stick to wire welding, the use of creeper carts to allow the worker to roll to the back of the honeycomb section where possible, the installation of automatic welding systems, and improved ventilation systems. The process has since been changed to an automated welding system which minimizes worker exposure to the occupational risk factors outlined previously.



### **IIID. Shear Operation in Plate Shop Possible Interventions**

The plate shear is used primarily to cut small pieces of material, for use in the ship fitting operations, out of large plate stock. Plates are cut into progressively smaller pieces, until finally cut into triangles from 1' x 1' squares. These pieces are then shipped out to the ship fitters in the yard. The primary concern for the plate shop shear operator or helper is the constant bending at the waist or kneeling to pick up material from the back of the shear at floor level. One possible solution is to provide an adjustable lift table for the shear chute at the back of the machine. In this way the cut material would still fall onto the back chute of the shear, and in turn onto the lift table. The lift table can be elevated, allowing the worker to transfer cut material at approximately waist height. This would eliminate the need for the worker to lift objects off the rear chute at near floor level.

A hydraulically operated lift table was chosen to alleviate the safety and ergonomic problems with the plate shear operation. This lift table is situated in a pit that was placed behind the plate shear. The pit is approximately 36"x132"x57", depth, length, and width respectively. The lift table fits inside of this pit, the top surface measures 46"x130", and has a range of motion of approximately 5' (2' below floor surface to 3' above floor surface). The controls for the lift table are placed to the side of the shear so that the table operator can have a clear view of the table, but cannot reach the table while it is in motion. This allows the operator to avoid being subjected to any pinch point hazards at the pit/table interface.

Initially the table was intended to allow manual stacking of the cut material at a higher more ergonomically correct height than floor level. After installation and some preliminary use, several methods were developed to mostly eliminate the stacking component of this task. Either a pallet, or a tote bin was placed on the lift table, and the material slid directly off of the shear onto or into the container. This was then moved directly, via crane or forklift, to the front of the shear for further cutting operations, or out to the yard as parts to be used in other operations.

The benefit of eliminating the pick-up and stacking portion of this operation has been two-fold. First, it has greatly reduced the ergonomic and safety issues long associated with this task, and second, it has increased productivity by reducing the amount of time required to cut and ship a piece of plate. It is no longer necessary to manually clear the drop-plate of the shear. This is done automatically by virtue of the pallet or tote box being placed below floor level. The shipping process is faster due to the fact that it is no longer necessary to move the pallet of finished plate to another location to be picked up by a forklift. Now the forklift can lift the container of finished plate directly off of the lift table. Also, the lift table has made the plate shear operation a single person job, instead of the previously required two to three people, all while maintaining a consistently higher production.

The cost of the hydraulic lift table for the plate shear included approximately \$4300 for the table and about \$300 for training in the use of the table. The cost of the pit and the installation costs also need to be considered, but were not specifically recorded.

The use of the hydraulic lift table at the rear of the plate shear has been very successful in reducing musculoskeletal and traumatic injuries associated with that task in the plate shop. The benefits have occurred largely due to the near total elimination the lifting/stacking phase of the job. Removing this phase has eliminated nearly all kneeling on concrete, and greatly reduced the manual materials handling, and thus the contact with sharp edges.

In addition to the ergonomic improvements, the lift table has increased productivity, according to plant personnel. This higher rate of productivity is a result of the lift table allowing the job to be done with just one person, instead of the previously required two. If an operator-helper team performs this task, total output can be increased. This increase results from not needing to stack each individual piece of material, and by the expedited material transport allowed by the catch containers.

#### **IV. CONCLUSIONS**

Four work processes within a barge building operation were surveyed to determine the presence of risk factors associated with musculoskeletal disorders and to arrive at possible interventions. The four work processes are a rake frame subassembly task, an angle iron unloading task, a confined space welding task, and a shear operation in the plate shop.

Six separate exposure assessment techniques were used to quantify the risk factors associated with the rake frame sub assembly task. A possible intervention would be to raise the work surface by installing a lift table to hold the jig pattern for the rake frame, eliminating the bent torso for much of the task. Welders who join the individual pieces of steel also exhibit awkward postures while working near floor level. By raising the work surface, these awkward postures are minimized. Further engineering analysis by Jeffboat personnel determined that there was insufficient floor space available to fully implement this intervention without impacting adjacent operations.

The unloading of angle iron in the steelyard was also analyzed with a number of exposure assessment techniques. The high amount of effort required to separate and flip individual pieces of long angle iron is the most significant problem associated with this process. Possible interventions include staggering the end of the bundle of angle irons, installing a breakup wedge system to encourage the stack of angle irons to loosen when dropped by the yard crane, and automating some of the processes to eliminate the pulling of angle irons into position across the roller conveyor. Jeffboat engineers considered alternative methods to automatically flip the angle iron pieces, but the methods were deemed too costly to justify implementation.

The honeycomb welder task in the manufacture of double hull sections requires the worker to enter a confined space and weld two seams between vertical supports and the bottom steel plate. This process can be improved from current conditions by changing ventilation set-ups, changing from stick to wire welding, or by automating the welding process. This last option may be most desirable to remove the worker from exposure to risk factors. Otherwise, the constrained postures, exposure to contact stresses to the knees and elbows, and exposure to some welding fumes would still be present. Creeper carts, as used in automobile repair garages, may allow the worker to travel to the back of the honeycomb section with less strain on their knees and back. As mentioned previously, the process has been changed to an automated welding process minimizing worker exposure to the occupational risk factors noted above.

The shear operator in the plate shop often bent at the waist to pick up pieces of steel, either from a supply bin or from the tray at the back of the shear machine. Manually lifting the pieces of steel from near floor level resulted in undue stress on the back of the workers. By incorporating lift tables or tilting pallet jacks into areas both in front and behind the shear machine one can minimize the stress on the workers' backs. This intervention was successfully implemented at Jeffboat.

It is suggested that further action can be taken to mitigate the exposure to musculoskeletal risk factors within each of the identified tasks. The implementation of ergonomic interventions has been found to reduce the amount and severity of musculoskeletal disorders within the working population in various industries. It has been suggested that ergonomic interventions may be implemented at Jeffboat to minimize the hazards in the identified job tasks.

Each of the interventions proposed in this document are to be considered preliminary concepts. Full engineering analyses by the participating shipyard are expected prior to the implementation of any particular suggested intervention concept to determine feasibility, both financially and engineering, as well as to identify potential safety considerations. Each intervention was developed for a particular set of circumstances and may not be directly transferable to other similar work situations.

## V. REFERENCES

- Hudock, S. D., S. J. Wurzelbacher, and O. E. Johnston. Preliminary Survey Report: Pre-Intervention Quantitative Risk Factor Analysis for Ship Construction Processes at Jeffboat LLC, Jeffersonville, IN. April 2000, Report No. EPHB 229-11a, NIOSH, Cincinnati, OH, 97 pp. Available at <http://www.cdc.gov/niosh/ergship/reports.html>.
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